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METHOD OF, AND APPARATUS FOR, THE TRANSMISSION OF A PLURALITY OF SIGNALS

The present invention relates to a method of, and apparatus for, the transmission of a plurality of signals. It relates particularly, but not exclusively, to the simultaneous transmission and distribution of Coded Frequency Division Multiplexing (COFDM) signals in a Cellular Access to Broadband Services and Interactive Television (CABSINET) microcell.

Transmission and distribution of digital video, for example to set-top boxes, in private homes (or elsewhere) is increasing due to schemes such as video on demand. In the past, such video signals have been transmitted via cable. However, technology is now available to transmit video signals via RF means to a number of end users. This development offers the advantage of not having to lay cables to individual private homes, which is labour intensive and causes environmental damage. Digital video signals are now able to be broadcast, via a base-station, (which transmits signals) to a number of micro-cells. These micro-cells may include a radio-repeater and a number of set-top boxes adapted to receive the transmitted digital video signals.

UK Patent GB 2 318 947 describes an intelligent digital beamformer and phased antenna array for installation in a satellite. The system provides multiple active beams within a footprint region for communications with a user on the earth surface. There is no reference to use the beamformer in a system which is capable of simultaneous transmission and distribution of COFDM signals.

US Patent 5 428 600 describes a system which simultaneously extracts, in the frequency domain, a narrow band BFSK carrier (received from Transmitter A) and de-spreads or correlates a wide-band CDMA signal (received from Transmitter Bi). The two signals are combined, using a phase modulator, to produce a frequency spectrum of a wide-band CDMA signal and BFSK carrier signal. The BFSK carrier is then used by receiving station B to assist with data recovery and demodulation.

An aim of the system described in the aforementioned US Patent is to extract the carrier signal and data from two remote sources for CDMA/FDMA and then to re-combine the signals for use by a receiving station.

European Patent Application No. EP 762 661 A2 discloses a channelised multi-carrier signal processor for equalising power levels of individual carriers of a multi-carrier signal to within a predetermined dynamic range. The signal processor splits a plurality of channels into individual channels using a 1:N power splitting stage and a mixing stage for analogue signal processing. The major disadvantage of this system is that there is significant degradation in the RF front-end receiver signal which is caused by the 1:N power splitter.

An aim of the present invention is to provide a method of, and apparatus for, the transmission and distribution of coded orthogonal frequency division multiplexed signals in order to transmit digital video signals to a plurality of end users.

According to a first aspect of the invention there is provided a method for the transmission of a plurality of coded orthogonal frequency division multiplexed signals, the method including the steps of: a) receiving a plurality of input signals; b) attenuating the input signals; c) band-pass filtering the attenuated signals; d) mixing the band-pass filtered and attenuated signals with a single frequency signal to provide mixed signals in a predetermined bandwith; e) attenuating the mixed signals; f) band-pass filtering the signals attenuated in step e); g) pre-amplifying the band-pass filtered signals from step f); h) attenuating the pre-amplified signals; i) amplifying the attenuated pre-amplified signals; j) band-pass filtering the signals amplified in step i; and k) transmitting the band-pass filtered signals from step j) to a plurality of receivers, so that each receiver, when suitably tuned, receives a separate transmitted signal.

Most preferably the signals are in the microwave region of the electromagnetic spectrum.

The method may also include the steps of providing static discharge protection and antenna port mismatch protection. One way of achieving this is to provide a DC block at a suitable point in the circuit.

The invention can be used to receive and transmit additional signals used for the synchronisation of, for example, data symbol rates and centre frequencies. These additional signals may be COFDM signals.

According to a second aspect of the invention there is provided an apparatus for the transmission of a plurality of coded orthogonal frequency division multiplexed signals including: a) means for receiving a plurality of input signals; b) first attenuating means for attenuating the said input signals; c) first band-pass filtering means for band-pass filtering the attenuated signals; d) single frequency generation means for generating a single frequency signal; e) mixing means for mixing the frequency of the first band-pass filtered signals with a single frequency signal to provide mixed signals in a predetermined bandwidth; f) second attenuating means for attenuating the mixed signals; g) second band-pass filtering means for band-pass filtering the attenuated mixed signals; h) pre-amplifying means for pre-amplifying the second band-pass filtered signals; i) third attenuating means for attenuating the pre-amplified signals; j) amplifying means for amplifying the attenuated pre-amplified signals; k) third band-pass filtering means for band-pass filtering the signals amplified in step j); and l) means for transmitting the third band-pass filtered signals to a plurality of receivers, so that each receiver, when suitably tuned, receives a separate transmitted signal.

The apparatus may also include dc signal blocking means for protecting the internal RF circuitry from static or other discharges.

Preferably the first attenuating means is an input switched intermediate frequency (i.e., generally higher in frequency than the data frequency, but lower in frequency than the carrier) attenuator, operating in the 0 dB to -70 dB range.

Preferably the mixing means for translating the frequency of the signals is a double balanced transmit mixer.

Preferably antenna port mismatch protection means such as a circulator may also be included in the apparatus.

The amplifying means for amplifying the signal may be an RF high power amplifier.

Preferably the means for transmitting the COFDM signal is a dual polarisation antenna.

Preferably the single frequency generation means includes a phase-locked oscillator, a high-stability oven controlled crystal oscillator and a band-pass filter.

Preferably the band-pass filter means is a low insertion loss band-pass filter such as, for example, an inter-digital filter.

A power supply means is provided in use and this may include: a linear power supply which may be used to provide a regulated power supply; and a switched mode power supply which may also be used to provide a regulated power supply.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying Figures, in which:-

Figure 1 shows a block diagram of a 5.8 GHz radio repeater; and

Figure 2 shows a block diagram of a system incorporating the repeater.

A 5.8 GHz radio repeater 2 having five stages is shown. It is capable of simultaneous transmission and distribution of fourteen Coded Orthogonal Frequency Division Multiplexed (COFDM) signals and one signalling channel in a Cellular Access to Broadband Services and Interactive Television (CABSINET) microcell. The repeater may be modified to handle more or less signals.

Referring in detail to Figure 1, the 5.8 GHz radio repeater includes an input switched intermediate frequency (IF) attenuator 10 (0 dB to -70 dB range), an 815 MHz band-pass filter 14 (FL1), an up-converting mixer 16, a high stability Oven Controlled Crystal Oscillator 36 (OCXO), a 4970 MHz phase locked oscillator 34 (PLO) , a 4970 MHz band-pass filter 32 (FL2), 5785 MHz band-pass filters 20, 28 (FL3, FL4), a 5785 MHz pre-amplifier 22, a 5785 MHz high power amplifier 26 and a 5785 MHz circulator 30.

Following IF attenuation and band-pass filtering with FL1, up-conversion of the 755 MHz to 875 MHz band to the 5725 MHz to 5845 MHz band is performed by the double balanced transmit mixer 16. The mixer output is filtered with FL3, a low insertion loss band-pass filter 20 such as, for example, an inter-digital filter. This filter 20 suppresses the local oscillator (LO) feedthrough from the mixer, and selects the upper sideband. The transmit buffer 22 pre-amplifies the selected sideband, easing the gain requirement for the 5785 MHz RF high power amplifier.

FL4, a low insertion loss band-pass filter such as, for example, an inter-digital filter, is used to further suppress both the transmit LO leakage and the undesired sideband.

The RF high power amplifier 26 boosts the transmit signal to a level of approximately +20 dBm (dB signal gain with respect to 1 mW) per channel, as measured at an antenna output SMA connection port. To satisfy the heavy supply current requirement of the high power amplifier 26, a switched mode power supply 44 is used.

Following FL4, a circulator 30 and DC block 38 are used to provide antenna port mis-match protection and static discharge protection, respectively.

The 8 dBi (dB gain with respect to an isotropic radiator) dual polarised directive antenna 40 consists of a linear array of stacked co-planar micro-strip patch antennae. The antenna 40 achieves an azimuth coverage of about 90 degrees.

The phase-locked oscillator (PLO) provides a tuneable (±2%) 4970 MHz LO signal from a +15 V 400 mA DC supply. The PLO 4970 MHz output is derived from a high performance 82.833333 MHz Oven Controlled Crystal Oscillator (OCXO). This OCXO has a temperature stability of ±0.025ppm over -20 to +60°C, ageing ±1ppm per year and pre-set frequency ±0.2ppm.

The 4970 MHz PLO produces over +10 dBm of output drive power from a 0 dBm input drive power. Phase noise performance is better than -96 dBc/Hz at 1 KHz offset. Output spurious signals are better than -73dBc (dB signal gain with respect to the signal carrier) at 275KHz, and output harmonics are better than -70dBc. FL2, a low insertion loss band-pass filter such as, for example, an inter-digital filter, is used to suppress undesired LO output harmonics. Following band-pass filtering with FL2, the 4970 MHz LO signal is applied to the up-converting mixer LO input port.

Two separate linear power supplies are used to provide regulated supplies to the OCXO and PLO. A switched mode power supply (SMPS) is used to provide a regulated supply to both the pre-amplifier and high power amplifier. All power supply units are 230 V ac 50/60 Hz mains driven and provide satisfactory ripple rejection and load regulation.

Tables 1 to 3 give the electrical, environmental and mechanical specifications, respectively, of the 5.8 GHz radio repeater of Figure 1 for the transmission and distribution of 14 COFDM signals.

LO = 4970MHz. IF = 815MHz. RF = 5785MHz. Z O = 50Ω. Unless Otherwise Specified

PARAMETER	SYMBOL	TEMP (°C)	ALL GRADES MIN	TYP	MAX	UNITS
OCXO CHARACTERISTICS (Vcc = +12.0V. Power = 5W switch on. 2W stable)						
OCXO Output Frequency	OCXO_OUT_f	25		82.833333		MHz
OCXO Frequency Stability (day of despatch)	OCXO_f1	25		±0.01		ppm
OCXO Frequency Stability (ageing per year)	OCXO_f2	25		±1.0		ppm
OCXO Temperature Stability (-20 to +60°C)	OCXO_T_f	25		±0.025		ppm
OCXO Output Power Level	OCXO_OUT_p	25		±1.5		dBm
OCXO Output Phase Noise	OCXO_OUT_pn	25		-105.5		dBc/Hz @ 1KHz
LO CHARACTERISTICS (Vcc = +15V. Icc = +400mA)						
LO Input Reference Frequency	LO_IN_f	25		82.833333		MHz
LO Input Reference Power Level	LO_IN_rp	25	-3	0	+3	dBm
LO Output Frequency	LO_OUT_f	25		4970		MHz
LO Output Tuning Range	LO_OUT_t	25		±2%		
LO Output Power Level	LO_OUT_pwr	25		+12	+13	dBm
LO Output Power Variation	LO_OUT_var	25			±1	dB
LO Output SSB Phase Noise	LO_OUT_pn	25		-96.2		dBc/Hz @ 1KHz
LO Output Spurious Signals at 275KHz	LO_OUT_sp1	25		-73		dBc
at 500Hz	LO_OUT_sp2	25		-55		dBc
LO Output Harmonics	LO_OUT_hr	25		-70		dBc
LO Output Impedance	LO_OUT_z	25		50		ohm
LO Load VSWR	LO_OUT_SWR	25		1.50:1		
TRANSMIT MIXER CHARACTERISTICS (LO_IN = 4970MHz/+12dBm, TXM_IF = 815MHz/-10dBm, RS IF = 50Ω, RS LO = 50Ω,RL RF = 50Ω)						
IF Input Frequency Range	TXM_IFf	25	DC		4000	MHz
RF Output Frequency Range	TXM_RFf	25	4.5		12	GHz
LO Input Power	LO_IN_pwr	25		+12		dBm
Isolation LO-RF	TXM_LEAK	25	+15	+23		dB
Conversion Loss	TXM_CL	25	-8.0	-9.0		dB
RF VSWR (4.5 to 12GHz)	TXM_OSWR	25		4.5:1		
RF Input Power (1dB Compression)	TXM_P1D	25		+4		dBm
RF Input Power (3rd Order Intercept. IP3)	TXM_IP3	25		+14		dBm
TRANSMIT POWER PRE-AMP CHARACTERISTICS (PRE_IN = 5785MHz/-20dBm, RS = RL = 50Ω, Vcc = +15V, Icc = 400mA)						
Power Pre-Amp Frequency Range	PRE_f	25	4		8	GHz
Power Gain	PRE_PG	25	+25	+33		dB
PRE_AMP Output 1dB Compression	PRE_P1D	25	+25	+26		dBm
PRE_AMP Noise Figure	PRE_NF	25		+2.00	+2.50	dB
PRE_AMP Output 3rd Order Intercept	PRE_IP3	25		+36		
PRE_AMP 2nd Harmonic at P1dB	PA_2H	25		-20	0	dBc
PRE_AMP 3rd Harmonic at P1dB	PA-_3H	25		-30	-10	dBc
PRE_AMP 3rd Order Intermodulation Ratio	PA_IMR	25				dBc
PRE_AMP Input VSWR	PRE_ISWR	25		1.60:1	2.00:1	
PRE_AMP Output VSWR	PRE_OSWR	25		1.75:1	2.00:1	
PRE_AMP Gain Flatness	PRE_GF	25		±1.75		dB
TRANSMIT POWER AMP CHARACTERISTICS (PA_IN = 5785MHz/-4dBm, RS = RL = 50Ω, Vcc = +15V, Icc = 2800mA)						
Power Amp Frequency Range	PA_f	25	5.4		5.9	GHz
Power Gain	PA_PG	25	+35	+40.5		dB
PA_AMP Output 1dB Compression	PA_P1D	25	+37	+37		dBm
PA_AMP Noise Figure	PA_NF	25		+4.10	+5.00	dB
PA_AMP Output 3rd Order Intercept	PA_IP3	25		+51		dBm
PA_AMP 2nd Harmonic at P1dB	PA_2H	25		-20	0	dBc
PA_AMP 3rd Harmonic at P1dB	PA_3H	25		-30	-10	dBc
PA_AMP 3rd Order Intermodulation Ratio	PA_IMR	25				dBc
PA_AMP Input VSWR	PA_ISWR	25		1.60:1	2.00:1	

PA_AMP Output VSWR	PA_OSWR	25		1.30:1	1.50:1	
PA_AMP Gain Flatness	PA_GF	25			+/-1	dB
TRANSMIT MIXER/POWER PRE-AMP/POWER AMP CASCADED CHARACTERISTICS (IF = 815MHz/-10dBm, IF Input Attenuator = -11dB, AL1 = -3dB, AL2 = -6dB, one HPA, one channel for IBC'98, four channels for Final Trial)						
UHF Input Frequency Range	UHF_INf	25	755		875	MHz
UHF Input Centre Frequency	UHF_IN_f	25		815		MHz
UHF Input Power	UHF_IN_pwr	25	-20	-10	+10	dBm
UHF Input Return Loss	UHF_IN_RL	25		+14		dB
RF Output Frequency Range	RF_OUTf	25	5725		5845	MHz
RF Output Centre Frequency	RF_OUT_f	25		5785		MHz
RF Output Frequency Stability (better than 0.45ppm @ 5785MHz)	RF_OUT_stab	25			+/-2.6	KHz
RF Output Return Loss	RF_OUT_RL	25		+11		dB
Cascaded Power Gain	CTX_PG	25		+51.5		dB
Cascaded Output NF	CTX_NF	25		+15		dB
Cascaded Output P1dB	CTX_P1D	25		+35		dBm
Cascaded Output 3rd Order Intercept	CTX_IP3	25		+45		dBm
Cascaded Output SSB Phase Noise	CTX_PN	25		-89.5		dBc/Hz @ 1KHz
Cascaded Output Power (one channel for IBC'98, four channels for Final Trial)	CTX_OP	25		+20		dBm
Cascaded Output Power Gain Control	CTX_GCTRL	25	0		+60	dB
Cascaded Gain Flatness	CTX_GF	25			+/-2	dB
Cascaded LO Leakage	CTX_LEAK	25		-104		dBm
Cascaded Group Delay (at lower edge of passband)	GD1	25			15	ns
Cascaded Group Delay (at upper edge of passband)	GD2	25			30	ns
Cascaded Relative Group Delay (GDR = GD2 - GD1)	GDR	25			15	ns
POWER SUPPLY UNITS						
AC Voltage Supply Range	V ac	25	220	230	240	Volts
AC Supply Current Range	I ac	25		5		Amps
Linear DC Supply Line Regulation	LINE_REG	25			10	mV
Linear DC Supply Ripple Rejection	RR	25			5	mV
Linear DC Supply Load Regulation	LOAD_REG	25			20	mV
SMPS DC Supply Ripple Rejection	S_RR	25			150	mV
SMPS DC Supply Load Regulation	S_LOAD_REG	25			±2	%

Table 1 - Electrical Specifications

			ALL GRADES			
PARAMETER	**SYMBOL**	**TEMP (°C)**	**MIN**	**TYP**	**MAX**	**UNITS**
TEMPERATURE RANGE						
Operating Temperature Range	OTR		0	+25	+50	degrees
Storage Temperature Range	STR		-20		+70	degrees

Table 2 - Environmental Specifications

Table 3 - Mechanical Specifications

PARAMETER	**TYP**	**UNITS**
Dimensions	350 x 390 x 160	mm
Mass	13.8	kg
RF Conn ctors	SMA (F)	
Mains Connector	IEC (M)	

Figure 2 is a diagrammatical, schematic view of a system comprising two users A and B and a repeater 2. In practice there may be many more users, but for simplicity only two are shown. User A (the so called Head End) can communicate to user 3 (the Consumer) via repeater 2 in order, for example, to play interactive television games or perform other two-way communications.

Although the invention has been described by one embodiment only, it will be appreciated that variation may be made to the aforementioned embodiment without departing from the scope of the invention. For example, the transmission of 5.8 GHz signals to fourteen receivers only has been discussed. However, other transmission frequencies and numbers of receivers are possible by varying, respectively, the OCXO 36 and PLO 34 centrc frequencies and the bandwidth of the band-pass filters 14, 20 and 28. For example, for 28 users, the bandwidth of the filters 14, 20 and 28 may be increased to 300 MHz. Similarly, although the invention has been described operating in a transmission mode, it may operate equally well in a receiving mode. Therefore the features of the invention may be incorporated into a receiver.